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ENERGY SCIENCES SUPERCOMPUTING 1990

Scientists of the Future: Learning by Doing

Will there be enough trained scientists, mathematicians, and engineers available in the future to keep the United States in the technological forefront? The National Energy Research Supercomputer Center (NERSC) is tackling this problem by giving high school students hands-on experience with supercomputers through two related programs.

The first program brings top math and science students to Lawrence Livermore National Laboratory for two weeks of work with NERSC's supercomputers. The second program, newly inaugurated, involves training high school teachers in the use of supercomputers so that they, in turn, can introduce scientific supercomputing to their students. To support this project, a one-processor Cray X-MP is being made available, through the cooperation of Cray Research, Inc., as an on-line resource to high school students across the country.

The "Superkids" Program

A select group of students—dubbed "superkids" by the NERSC staff—spent two weeks on site in June 1990. The sixth annual National High School Supercomputing Honors Program drew 58 students—one chosen by the governor of each state, the District of Columbia, and Puerto Rico. (In addition, a few foreign nations are invited to send participants.)

The students learned how supercomputers are used in scientific research, and in workshop settings they performed computer-generated three-dimensional graphic images. The students also toured research projects at LLNL and had the opportunity to talk at length with laboratory scientists.

Near the session's end, several students summed up their experience.

"I used to think science was a boring field, only for special people," said Nohemi Molina of Mexico. "I thought scientists weren't very interesting and wer[e]n't really in touch with people."

Now she's changed her mind. "I now see scienc[e as] available for anybody to get into. This program ha[s] encouraged us to get into science and to make goo[d in] that field."

Jeb Willenbring of North Dakota was particularl[y] interested in the algorithms used to solve problem[s and] in how problems are broken up for computational [pur]poses. "With supercomputers, you can do math pr[ob]lems that you used to think about but couldn't do," [he] said. "For example, the number of calculations it t[akes] to make one graphic image is mind-boggling."

"This experience makes you realize how much there still is to learn," he said. "When you learn something new, that only opens up more things to learn."

Roger Flugel of Connecticut was impressed with seeing the experiments in laser and magnetic fusion and liked talking with the scientists who conduct that research—he thinks he might someday be interested in working in one of those areas.

"This program has opened my eyes to large-scale simulation," he said. "I've seen the value of it and learned how complicated such simulations can be."

The program is one of several high school "honors" programs sponsored by the U.S. Department of Energy (DOE) at national laboratories. NERSC, with the initial session in 1985, was the first DOE facility to offer such a program. The most recent group of students brings to 337 the total number of participants.

Teaching the Teachers

In the second program, which ran concurrently with the first, six high school teachers—from Wisconsin, California, and the District of Columbia—spent three weeks at NERSC in a DOE-funded pilot workshop designed to bring supercomputing directly to their classrooms. The idea is to use supercomputing as both a teaching tool and a catalyst to spark student interest in science and math.

"With this program, we're reaching beyond just a select group of bright students," said John Fitzgerald, assistant director, planning and finance, at NERSC and a key champion of the new program. "Each of these teachers has 150 to 200 students who will now have access to a very attractive resource in the form of a supercomputer. We hope this makes their coursework more interesting and that it will entice more students into science or math."

During the session, the teachers spent two weeks learning the basics of supercomputing along with the honors students. In the third week, they concentrated on curriculum development, working on specific ways to incorporate supercomputing into the courses they teach.

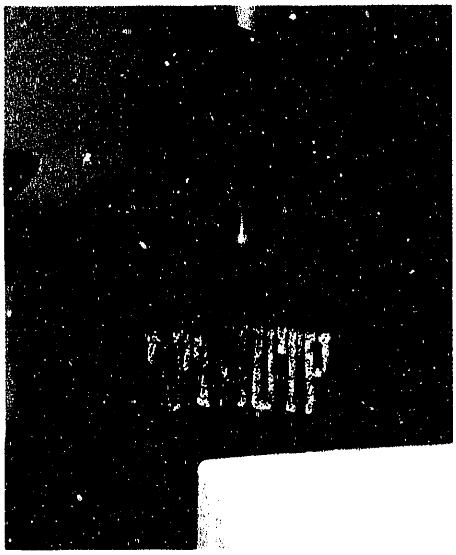
At the end of their stay, the teachers were enthusiastic about supercomputing's possibilities and were full of ideas for passing their excitement on to their students.

"I plan to use some of the projects we did on an interactive demonstration basis," said Mark Klawiter, who teaches chemistry and physics in Ladysmith, Wisconsin. "I'll use this class-wide and also with individual students who show a lot of interest in computer programming. I want them to use the supercomputer as a real scientist might and to come up with their own ideas. This will let students experience or 'do' science. They can conjure up their own uses and explore them."

In addition to using the computer as a teaching tool (for example, looking at particle motion), he planned to introduce supercomputing as a discussion topic, emphasizing the interactions of science, technology, and society.

Steve Harmon, who teaches math in Oakland, California, envisioned setting up group projects to illustrate the application of math concepts—perhaps having students use the supercomputer to compile a data base on the environmental history of a lake or pond. "Kids learn by doing science and practicing math," he said, "and there's no better format than a real-world project. That's how real learning takes place. Kids have ideas, in raw form, and that's an important part of science."

"Using the supercomputer will be something that makes a difference," Harmon continued. "You have to get the students excited— you try to get them to do their own science. By bringing specialized information to their level, they can be a part of it."



Tim Emholtz, who teaches math and computer science in New Richmond, Wisconsin, would like to see every one of his students exposed to supercomputing. He expects that levels of capability will vary but hopes that some students will be especially ignited.

"This is the kind of thing that will make better students," he said. "The students are going to be online with supercomputers, which they've never had an opportunity to do before, and that's exciting. It's the difference between hearing about something and doing or seeing it first hand, which is the fun way for kids to learn."

"These machines are capable of a lot of power," he said, "and the kids are capable of just as many amazing things. When you put the two together, it's exciting to think about."

Making Connections

One important goal of the program is to establish a link between the big science that occurs at the national laboratories and the teachers and students of high school science and math—to bring that kind of science directly into the classroom. "We want to provide a network for the teachers and students," said Fitzgerald, "and to develop a sense of community between the scientists here and people in the classroom."

The teachers seemed particularly grateful for that connection.

"Sometimes it feels like we're operating in a vacuum," said Klawiter. "This has helped bridge the gap with scientists. Now I know that if I need to consult, they're just a phone call away and willing to help. That's going to be great."

Emholtz also spoke of bridging the gap. "It's frustrating trying to keep up in computer science, because there are so many changes, so fast," he said. "After teaching 180 to 200 students and prepping for three different classes, I don't have much time left to do research or even reading. I was surprised with the ease with which the scientists here were able to communicate at my level and at their willingness to facilitate my growth. This experience has bridged the gap temporarily and has also provided an avenue for building a long-term bridge."

Expanding the Scope

In a related effort, NERSC's Brian Lindow in July led a two-week supercomputing workshop at Eau Claire, Wisconsin, for another 12 high school teachers.

All of these newly trained teachers—and their students—will have access to the Cray X-MP, christened the "National High School Supercomputer." NERSC, DOE, and Cray Research are joining together to make the supercomputer available for this purpose, and the NERSC staff will provide support to the teachers as they implement this project.

"This year's summer workshop was a first step," said Fitzgerald. "In the future, we'd like to see more teachers involved. This supercomputer is a unique educational resource, and we'd like to see it used not only in the classroom but also by kids in science and computer clubs or in gifted student programs, or perhaps even by scout troops. Just like supercomputing itself, the possibilities are enormous." ■

—G.V.K.

For more information about these programs, contact Sue Wiebe at (415) 423-9394.

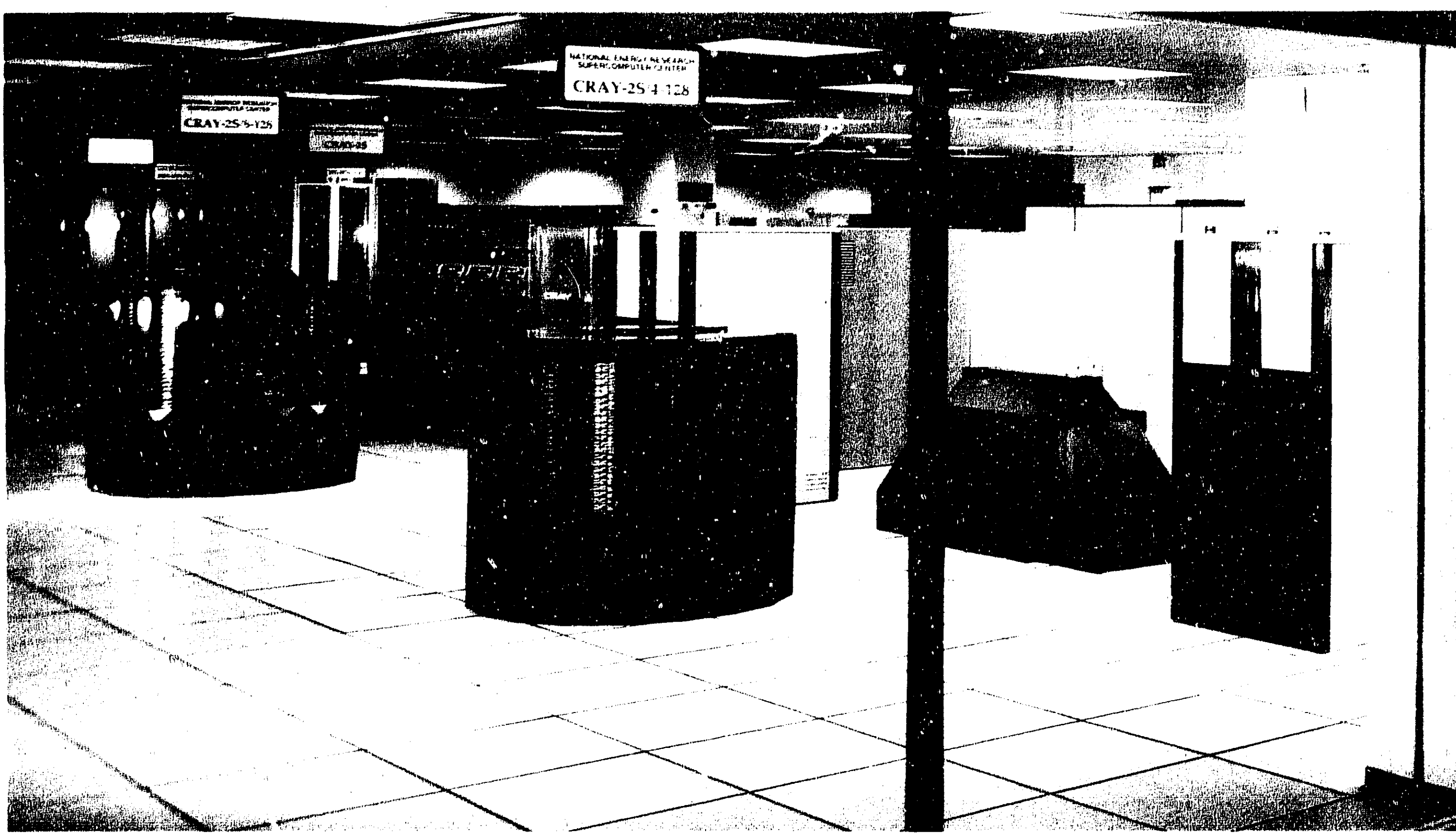
About the National Energy Research Supercomputer Center

The National Energy Research Supercomputer Center (NERSC) provides supercomputing capability for researchers whose work is supported by the Office of Energy Research (OER) of the Department of Energy. Currently there are about 4,500 people who use our supercomputers. These users work within nearly 150 different institutions across the United States, including national laboratories, universities, private laboratories, and industrial organizations. The OER programs we serve include (1) Magnetic Fusion Energy, (2) Superconducting Super Collider, (3) High Energy and Nuclear Physics, (4) Basic Energy Sciences, and (5) Health and Environmental Research.

Initially called the Controlled Thermonuclear Research Computer Center and later known as the National Magnetic Fusion Energy Computer Center, NERSC was formed in 1974 to meet the computational demands of the national magnetic fusion energy program. This center was the first organization to provide centralized supercomputing via network access. In 1983, OER expanded the center's role to provide service to other OER projects besides those in magnetic fusion. This expanded purpose was officially recognized in April 1990, when we acquired our present name.

NERSC now has four multiprocessor supercomputers available to users: a Cray-2 with eight processors and 134 million words of memory, a Cray-2 with four processors and 134 million words of memory, a Cray-2 with four processors and 67 million words of memory (serial 1), and a Cray X-MP with two processors and 2 million words of memory. All of these Crays operate with the Cray Time-Sharing System (CTSS). Within the next couple of years we anticipate acquiring a next-generation supercomputer.

A newly installed network, called ESNET (for Energy Sciences Network), connects various user sites across the United States to the central facility at Livermore and to each other. ESNET, which NERSC administers for the Department of Energy, supports several transmission protocols (for example, TCP/IP and DECNET), thus facilitating service to different



research communities. The ESNET backbone, based on fiber-optic technology, supports data transmission at the T1 rate (1.5 million bits per second). ESNET is cross-connected to several other major backbone networks (for example, NSFNET) and has international connections to Europe and Japan.

Our archival file storage system is the Los Alamos Common File System (CFS), which uses as its main storage mechanism a Storage Technology Corporation automated cartridge system, with the storage cartridges accessed robotically. The present storage capacity of this system is about 4 trillion bytes.

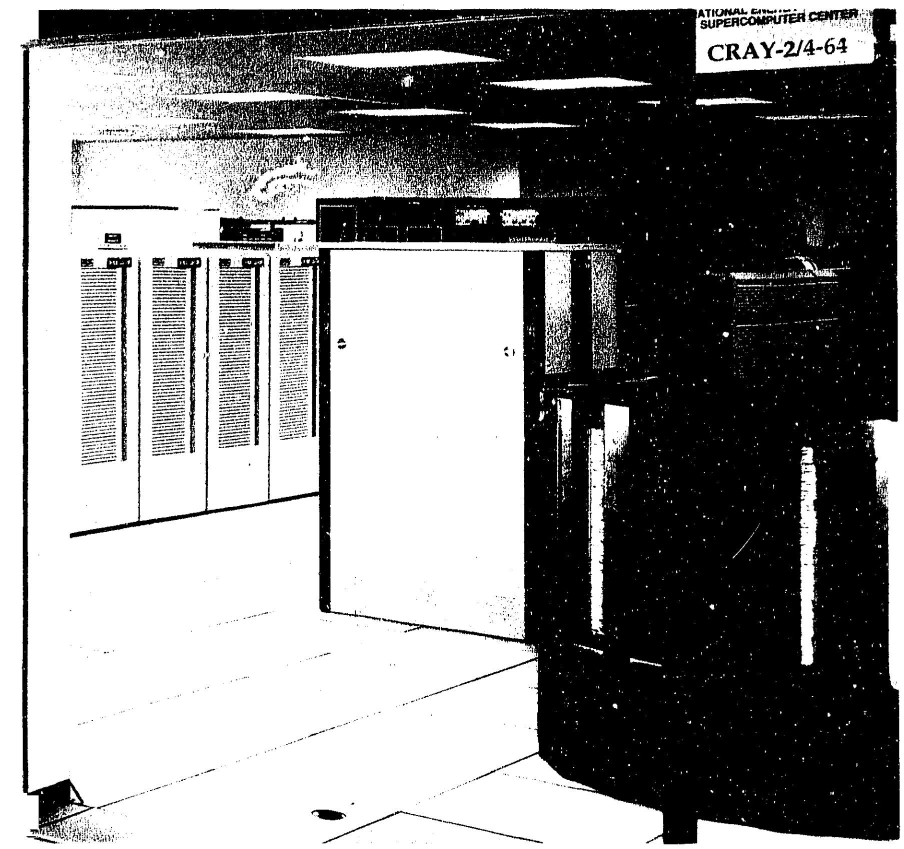
The supercomputing environment at NERSC includes an array of services for users:

- General consulting.
- Network information, support, and troubleshooting.
- User training and education.
- Support of on-line bulletin boards.
- A monthly newsletter (the *Buffer*) that focuses on systems issues and applications.
- An electronic mail system that supports return receipts and attached files for communications within the NERSC domain.
- On-line documentation with a menu-driven interface.
- A library of applications code abstracts containing more than 300 entries.
- Con. ulting support for more than 70 applications codes.

We have available a number of important user libraries, and we actively support the multitasking of applications codes. We also provide advanced graphics software, such as the visualization tools produced at the National Center for Supercomputing Applications. ■

—*A.A.M.*

INSTANT ACCESS. Data can now move through ESNET's fiber-optic circuits at a rate of 1.5 million bits per second, connecting research centers with each other and with the NERSC supercomputers. From the control center at NERSC, operators keep track of ESNET's performance and, if necessary, troubleshoot via remote control.



A ROOMFUL OF POWER. The red-clad superstars of the NERSC machine room are, left to right, a Cray X-MP (tall and to the rear), an eight-processor Cray-2, a four-processor Cray-2, and a second four-processor Cray-2 (at extreme right). Combined, the four supercomputers online to NERSC users have 18 processors and 337 million words of memory, with a peak computing capacity of 8.2 billion arithmetic operations per second. (In the time it typically takes to read this caption, these machines can perform about 180 billion arithmetic operations.)

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